PROJECT TITLE: Strengthening Regional Climate Resilience and Supporting Green Economic Recovery through Ecosystem-Based Adaptation and Sustainable Livelihoods in the Dominican Republic, Antigua and Barbuda, and Jamaica

PROJECT NUMBER: EbA3_013

ASSIGNMENT: Literature review of social-ecological climatic vulnerabilities/ risks relevant to the Oracabessa area to inform adaptation actions, including development of livelihood interventions, strengthening of existing sustainable livelihoods and coral restoration activities.

Wardens Patrolling the Oracabessa Marine Protected Area

Photo: Ava-Gail Gardiner

Introduction

This literature review was produced as part of a project (the EbA Caribbean project, see below) that aims to use Ecosystem-based Adaptation (EbA) approaches to address climate change threats to coastal ecosystems and communities across the Caribbean. These threats include increased sea temperatures, sea level rise, more frequent and severe hurricanes and changing rainfall patterns. The impacts of climate change exacerbate existing environmental problems and the cumulative effects degrade coastal ecosystems that are crucial to the livelihoods of coastal communities.

To enhance the resilience of coastal ecosystems and the communities that are dependent on them, the "EbA Caribbean" project, formally entitled "*Strengthening regional climate resilience and supporting green economic recovery through ecosystem-based adaptation (EbA) and sustainable livelihoods in the Dominican Republic, Antigua and Barbuda, and Jamaica*," was initiated. The project aims to address three primary objectives:

1. **Restoration and conservation of marine-coastal ecosystems** to reduce exposure to climate change hazards and provide essential goods and services that support community well-being and resilience.

2. **Diversify and strengthen existing sustainable, climate-resilient natural resource-based livelihoods** for local communities, with a special emphasis on vulnerable groups, women, and youth, to build adaptive capacity and reduce the degradation of marine-coastal environments.

3. **Developing an EbA knowledge platform** to store, share, and disseminate scientific information, local knowledge, and experiences related to ecosystem-based adaptation. This platform aims to enhance south-south learning, connect various actors across sectors and levels, and strengthen the evidence base on EbA outcomes to inform good practices and scale-up efforts.

~~The objectives of this literature revieewthe project are to:~~

~~1. Understand the current state of coastal ecosystems in the Caribbean (especially in project target areas such as Oracabessa, St. Mary, Jamaica) and the various climate change stressors impacting them.~~

~~2. Assess the effectiveness of existing strategies and practices in restoring and conserving these ecosystems.~~

~~3. Identify the challenges and opportunities in implementing sustainable, climate resilient livelihoods in coastal communities.~~

~~4. Explore the potential of knowledge sharing platforms in enhancing regional climate resilience and supporting sustainable livelihoods through ecosystem-based adaptation.~~

~~5. Provide insights and recommendations to improve the design and implementation of the EbA Caribbean project, ensuring it meets its objectives and contributes significantly to the resilience of coastal ecosystems and communities in the region.~~

Purpose of the Literature Review

This literature review supports the Caribbean EbBA project's activities in Oracabessa in the following ways:

1. Assessment of Climate Vulnerability and Risk:

Identify and understand the current state of climate vulnerability and risk specific to Oracabessa. This includes examining published material that documents the various climate change stressors and their impacts on both ecosystems and communities, and complements insights from community consultations and the expertise of staff of Oracabessa Marine Trust.

2. Evaluation of EbA Measures:

Assess the potential effectiveness of different Ecosystem-based Adaptation (EbA) measures to address the vulnerabilities identified. This evaluation will focus on how coral restoration and livelihood interventions can be used to minimize climate vulnerability.

3. Support the development of a Climate Adaptation Action Plan:

The insights gained from the literature review together with information obtained during consultations with the community and work on the project's Theory of Change will inform the development of an adaptation action plan for the ~~EBA~~ EbA project in Oracabessa.

Format of the Literature Review

The review is structured in 3 parts.

Part I presents the overarching framework for climate change adaptation in Jamaica; summarizing Jamaica's climate change policy, institutional framework and national communications.

Part II presents information on the climate change vulnerabilities faced by the community of Oracabessa. It assesses the current climatic changes being experienced and evaluates the potential impact of future climate change.

Part III evaluates the use of ~~EBA~~ EbA ~~restoration and livelihood adaptation~~ measures as tools for adaptation as well as the climate vulnerability of these measures themselves.

PART I: Policy Context

The GOJ has made several commitments to climate change adaptation and mitigation. The Caribbean EBA project in Oracabessa is well aligned with these commitments. ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995. ~~As a Party to the Convention, Jamaica is obligated to prepare its National Communications (NCs) to the UNFCCC. To date, Jamaica has completed three NCs and is currently advancing the proposal to develop its fourth NC. In April 2017, Jamaica became a Party to the Paris Agreement, committing to the global efforts to reduce greenhouse gases with the implementation of its periodically submitted Nationally Determined Contributions (NDC). Jamaica submitted its initial NDC in November 2015 and updated it in June 2020.~~ Table 1 below highlights the National Adaptation Plan (NAP) process and instruments at the national, regional, and international level.

Table 1: Overarching legal instruments addressing climate change in Jamaica.

Year	National Adaptation Processes and Instruments	Framework
1995	United Nations Framework Convention on Climate Change (UNFCCC)	International
1999	Kyoto Protocol	International
2000	Initial National Communications to UNFCCC	International
2009	Vision 2030 Jamaica – National Development Plan	National
2011	Second Communications to UNFCCC	International
2015	Climate Change Policy Framework for Jamaica	National
2015	Intended Nationally Determined Contribution (NDC)	International
2017	Paris Agreement; ratified	International
2019	Third National Communications to UNFCCC	International
2020	Updated Nationally Determined Contribution (NDC)	International
2020	Doha Amendment	International

National Goals and priorities:

1. *Nationally Determined Contribution (NDC):*

- ~~Jamaica submitted its first NDC in 2015 and updated it in 2020, which reflects its commitments under the Paris Agreement.~~[1]

- ~~Mitigation: Jamaica aims to reduce its greenhouse gas (GHG) emissions by 25.4% below the business-as-usual scenario by 2030. The main sectors targeted for these reductions are the energy sector (specifically electricity generation and transportation) and the land use change and forestry sector.~~

- Adaptation: The NDC ~~also~~ outlines adaptation priorities ~~(~~in a range of sector including~~s~~ ~~not covered by its quantitative commitments) focusing on sectors like~~ water, health, coastal zones, agriculture and fisheries.

The updated NDC, 2020 underscores that the "*Climate Change Policy Framework for Jamaica (2015)* identifies the agriculture and fisheries sector as a critical sector of importance for both mitigation and adaptation. Strategic aims include facilitating the use of water (and energy) efficient agricultural methods, improved food storage systems, and diversifying food production techniques including the expansion of agroforestry and aquaculture[2]. Consistent with these strategic priorities, several important ongoing projects in the sector are contributing to both GHG emissions reductions, carbon sequestration and enhanced climate resilience."[3]

2. *National Communications to the United Nations Framework Convention on Climate Change*:

National communications have provided a basis on which to conduct assessments and identify sectors most vulnerable to climate change. Jamaica's Second National Communications (NC) to UNFCCC identified water, human health, agriculture, coastal resources and human settlement and tourism as the priority sectors.

The Third NC recognised that these sectors remain vulnerable yet crucial, and also provides Jamaica's inventory of its Greenhouse Gas (GHG) emissions for the period 2006-2012. Vulnerability assessments were conducted for each priority sector to determine the island's vulnerability to the impacts of climate change for the priority sectors. N.B. The agriculture sector, one of the priority sectors, includes fisheries; note that the vulnerability assessments conducted for agriculture and fisheries are included in the Third National Communication~~s~~ (TNC).

3. *National Adaptation Plan (NAP):* Jamaica's NAP focuses on mainstreaming climate change adaptation into planning and decision-making at all levels. Priorities include: enhancing knowledge management and capacity building, strengthening institutional and regulatory

[1] ~~See, https://unfccc.int/NDCREG~~

[2] And by extension to mariculture, which includes the seamoss project being spear-headed by OMT.

[3] See UNFCC. 2020. Jamaica's Updated Nationally Determined Contribution, at https://unfccc.int

frameworks, promoting investment in climate-resilient infrastructure, and enhancing disaster risk management and response.

4. Vision 2030 Jamaica – National Development Plan: Jamaica's long-term development plan, aiming to make Jamaica "the place of choice to live, work, raise families, and do business" by 2030. Climate change is integrated across multiple sectors and thematic areas, emphasizing both mitigation and adaptation.

Climate change is primarily addressed under National Goal #14 'Hazard Risk Reduction and Adaptation to Climate Change' but is recognized as cross-cutting for other outcomes and strategies of the Plan. The key related national strategies are: (i) develop measures to adapt to climate change, and (ii) develop mechanisms to influence the global rate of climate change. The Plan articulates national strategies including improving resilience to all forms of hazards (e.g. expanding early warning systems), improve emergency response capability, development measures to adapt to climate change (e.g. through education, research, 'climate-proofing' policies), contribute to the effort to reduce the global rate of climate change (e.g. reducing deforestation rate through reforestation programmes). Similarly, gender equality is identified as a cross-cutting priority.

Vision 2030 Jamaica also addresses the issue of food security, and aims to: support national food security through various strategies including the alignment of food policies with nutritional goals and the support of safe food production; and transform the agricultural sector with a focus on high-value production contributing to national food security.

The Plan's approach is fairly comprehensive, integrating environmental sustainability into socio-economic decision-making and prioritizing the reduction of rural poverty and the enhancement of agricultural systems. Note: Efforts are underway to revise the Vision 2030 Agriculture Strategy Action Plan within the next two years, which provides an opportunity for stronger direction and climate change focus.

Climate Change Policy Framework (NCCPF)

"It is recognized that given the cross-cutting nature of climate change, there is an urgent need to develop an integrated approach in order to effectively build resilience at all levels and to have the required enabling policies in place".[4]

In 2015 Jamaica produced an overarching *Climate Change Policy Framework* which took into account *Vision 2030 Jamaica - National Development Plan*[5] and *Jamaica's Second National*

[4] National Climate Change Policy Framework (NCCPF), 2015

[5] ~~Jamaica's sustainable development imperatives are guided by Vision 2030 Jamaica – National Development Plan. Vision 2030 Jamaica provides the framework to ensure that climate change issues are mainstreamed into national policies and development activities. The issue of adaptation to climate change is specifically addressed under National Outcome #14 'Hazard Risk Reduction and Adaptation to Climate Change'. The key related national strategies are: (i) develop measures to adapt to climate change, and (ii) develop mechanisms to influence the global rate of climate change~~

Communication on Climate Change to the United Nations Framework Convention on Climate Change.[6]

The Climate Change Policy Framework for Jamaica is intended primarily to support the goals of Vision 2030 by reducing the risks posed by climate change to all of Jamaica's sectors and development goals. It outlines the objectives, principles and strategies that the country will employ in order to effectively respond to the impacts and challenges of climate change, through measures which are appropriate for varying scales and magnitudes of climate change impacts.

Specifically, the goal of the Policy Framework is to create a sustainable institutional mechanism to facilitate the development, coordination and implementation of policies, sectoral plans, programmes, strategies, and legislation to address the impacts of climate change.

The objectives of the Policy Framework are:

I. To mainstream climate change considerations into national policies and all types and levels of development planning and to build the country's capacity to develop and implement climate change adaptation and mitigation activities.
II. To support the institutions responsible for research, data collection, analysis and projections at the national level on climate change, its impacts, and appropriate adaptation and mitigation measures, to facilitate informed decision-making and strategic actions at all levels.
III. To facilitate and coordinate the national response to the impacts of climate change and promote low carbon development.
IV. To improve communication at all levels on climate change impacts and also adaptation and mitigation related opportunities so that decision makers and the general public will be better informed.
V. To mobilize climate financing for adaptation and mitigation initiatives.

Sector Strategies and Action Plans

At the sector level, the respective Ministries, Departments and Agencies (MDAs) have the main responsibility to develop SSAP which integrates climate change. In some instances, vulnerability assessments have been conducted with a view to informing the content and focus of SSAPs.

Sector Strategy and Action Plans have been prepared for priority sectors, including water and coastal resources and fisheries. Below is a summary of key climate change strategies developed for agriculture and fisheries.

[6] ~~Jamaica's Second National Communication (SNC) on Climate Change assessed climate change impacts for some key sectors, namely health, human settlements, and tourism, in addition to revisiting agriculture, water, and coastal zones, for the years 2015, 2030, and 2050. Jamaica's SNC also includes an assessment of potential mitigation options to reduce greenhouse gas (GHG) emissions over the period 2009 to 2030 as well as to improve energy efficiency. The SNC provides an outline of proposed strategies for awareness raising, a review of the national systematic observation systems, and a technology needs assessment.~~

Agriculture: The Agriculture Sector has developed an Agriculture Disaster Risk Management (ADRM) and Climate Change Adaptation Framework and Strategy. The framework articulates the structure, mechanisms, rules, norms and inter-relationships that will govern the mainstreaming of disaster risk management and climate change adaptation in the agriculture sector and sub-sectors.

Fisheries: The Fisheries Sector has drafted a *Fisheries Sector Strategy and Action Plan* with support from Caribbean Community Climate Change Centre (CCCCC). Work is ongoing to further refine the governance frameworks for the fisheries sector, including updates to the draft policy.

Policy priority # 4 of the *MOAF 2019/20 – 2022/23 Strategic Plan* commits to "Build climate-resilient agriculture, fisheries, manufacturing and services sectors with its goal "To develop a climate-resilient agricultural sector and to increase the adoption of climate resilient practices among targeted farming and fishing communities in Jamaica."

Adaptation Communication for Jamaica (2022)

Jamaica's most recent submission to the UNFCCC was the Adaptation Communication (2022) that defines the country's climate adaptation strategies. This key document highlights several risks and mitigation approaches specifically for coastal communities, including the following:

1. Coral Restoration: Recognising that climate change poses risks like increased sea temperatures and acidity, which can damage coral reefs, defined adaptation strategies include promoting coral resilience through restoration projects and protective legislation.

2. Fisheries: Acknowledging that rising temperatures and changing sea conditions are adversely affecting fish populations, the Adaptation Communication sets out a commitment to promote sustainable fishing practices and enhance the resilience of marine ecosystems in Jamaican waters.

3. Mariculture (Sea Moss Cultivation): Sea moss faces threats from ocean acidification and extreme temperature changes. The Adaptation Communication mentions strategies such as improving mariculture practices and implementing systems that can withstand adverse conditions.

International Context

Jamaica's policies are being developed against the backdrop of a dynamic international context which is increasingly being influenced by scientific research. The Intergovernmental Panel on Climate Change (IPCC)[7] reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide relevant to the understanding of climate change. Focusing on presenting an objective analysis of the data available globally

[7] The Intergovernmental Panel on Climate Change (IPCC) is an international body established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988. Its primary purpose is to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

and providing assessments that are essential for governments and decision-makers to develop climate-related policies, the IPCC plays a key role in framing Jamaica's policy.

The IPCC works through three Working Groups and a Task Force:

1. Working Group I deals with the physical science basis of climate change.
2. Working Group II addresses climate change impacts, adaptation, and vulnerability.
3. Working Group III focuses on the mitigation of climate change.

Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report - Working Group II Report - Climate Change 2022: Impacts, Adaptation and Vulnerability[8]

The Working Group II contribution to the IPCC Sixth Assessment Report assesses the impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change.

The latest scientific consensus from the IPCC emphasizes the increasing impacts of climate change, especially on coastal communities and natural resources. According to the Sixth Assessment Report (AR6) from the IPCC, several key projections and impacts are highlighted:

1. Increased Sea Level Rise: Coastal communities are particularly vulnerable to rising sea levels, which can lead to erosion, increased flooding, and loss of habitat for fish and other marine life.

2. Ocean Acidification and Warming: The health of marine ecosystems is at risk due to increased ocean temperatures and acidification. These conditions stress coral reefs and threaten fisheries and mariculture, including the cultivation of species like sea moss.

3. Extreme Weather Events: More frequent and severe hurricanes and tropical storms can devastate coastal infrastructures, ecosystems, and communities.

4. Economic Impacts: The economic sustainability of communities that rely on fisheries and tourism can be significantly disrupted by changes in oceanic conditions.

Adaptation strategies recommended by the IPCC include building resilient infrastructure, enhancing coastal protection through natural and artificial means, and implementing ecosystem-based management practices. These measures aim to reduce vulnerability and increase the resilience of both human and natural systems to the ongoing changes driven by climate change.

[8A] See: https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-15/

The IPCC 2023 Synthesis Report which integrates findings across various aspects of climate change research, further underscores climate risks for coastal communities by highlighting increased risks from sea-level rise, storm surges, and coastal erosion.

The Synthesis Report emphasizes the need for comprehensive risk management strategies, which include integrating nature-based solutions, improving coastal defence, and enhancing early warning systems to minimize the impact of extreme events. For adaptation, the report suggests strengthening infrastructure resilience, community-based adaptation initiatives, and policies that support sustainable coastal management practices.

The Synthesis Report makes reference to the *Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)*, produced by the IPCC in 2022.

The **Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)** [9] highlights significant changes affecting marine and polar environments. Key findings include:

- Accelerated rates of ocean warming and increased frequency of marine heatwaves.

- Ongoing ocean acidification and reduced oxygen levels, impacting marine life and ecosystems.

- Significant ice loss from glaciers and ice sheets contributing to sea level rise.

- Increased coastal flooding and extreme sea level events, threatening ecosystems and communities.

Given the specific focus of the SROCC, a number of its findings are particularly poignant and are worthwhile restating below:-

A.2 “It is virtually certain that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system. Since 1993, the rate of ocean warming has more than doubled. Marine heatwaves have very likely doubled in frequency since 1982 and are increasing in intensity. By absorbing more CO2, the ocean has undergone increasing surface acidification. A loss of oxygen has occurred from the surface to 1000 m…”

A.3 “Global mean sea level (GMSL) is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets, as well as continued glacier mass loss and ocean thermal expansion. Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and coastal hazards…”

A.6 “Coastal ecosystems are affected by ocean warming, including intensified marine heatwaves, acidification, loss of oxygen, salinity intrusion and sea level rise, in combination with adverse effects from human activities on ocean and land (high confidence). Impacts are

[9]See: https://www.ipcc.ch/site/assets/uploads/sites/3/2022/03/01_SROCC_SPM_FINAL.pdf.

already observed on habitat area and biodiversity, as well as ecosystem functioning and services."

A 6.4 "Warm-water coral reefs and rocky shores dominated by immobile, calcifying organisms such as corals, barnacles and mussels, are currently impacted by extreme temperatures and ocean acidification. Marine heatwaves have already resulted in large-scale coral bleaching events at increasing frequency causing worldwide reef degradation since 1997, and recovery is slow (more than 15 years) if it occurs…"

The IPCC Sixth Assessment Report[10] focuses on Impacts, adaptation and vulnerability and Chapter 15 focuses specifically on Small Islands, [11] examining the climate change impacts and projected risks faced by small islands, including the detection and attribution of observed impacts, the losses and damages they experience, and the enablers, limits and barriers to the implementation of adaptation options applicable to them. The implications of climate change impacts on the attainment of the Sustainable Development Goals (SDGs), the need for more climate resilient development pathways based on a systems transitions approach, and how both of these intersect with future potential responses are assessed within the context of small island states.

Figure 15.1 below presents a schematic illustration of the interconnections of Chapter 15 themes, including on observed impacts and projected risks (Section 15.3) and on adaptation options and their implementation (Sections 15.5 and 15.6).[12]

[10] IPCC, 2022: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

[11] Mycoo, M., M. Wairiu, D. Campbell, V. Duvat, Y. Golbuu, S. Maharaj, J. Nalau, P. Nunn, J. Pinnegar, and O. Warrick, 2022: Small Islands. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2043–2121, doi:10.1017/9781009325844.017. Available at: https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-15/

[12] Available at https://www.ipcc.ch/report/ar6/wg2/figures/chapter-15/figure-15-001

Schematic illustration of the interconnections of Chapter 15 themes

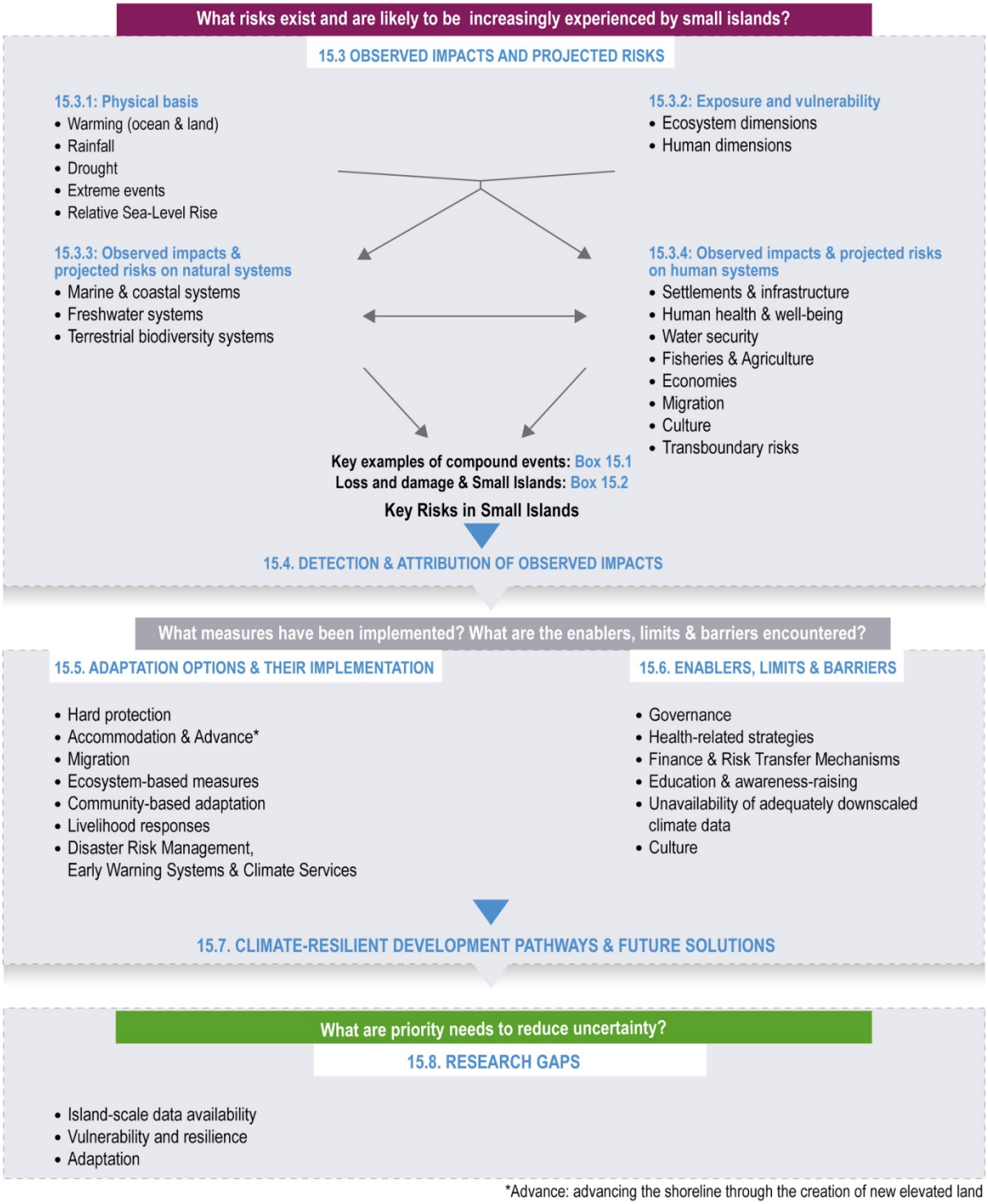


Figure 15.1

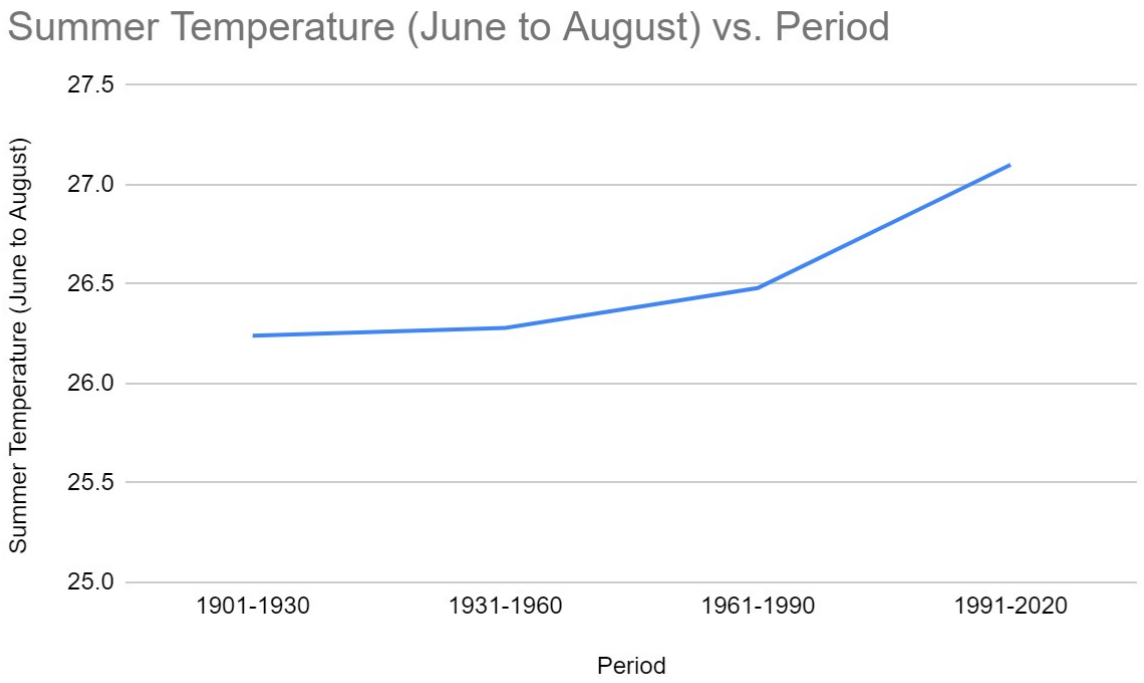
PART II: Current and projected climate change impacts

Community level information on climate change impacts and adaptation is limited. Consequently, information related to regional and national climate change impacts and trends was used to evaluate current and future threats to the community.

The lifestyles and economies of Caribbean communities are specifically adapted to their climatic setting. Climate extremes have major impacts on agriculture, fisheries, human health, tourism, water availability, recreation, and energy usage, among other things (Taylor et al., 2012). Warmer atmospheric temperature, rising sea levels, and increased frequency and intensity of weather events such as hurricanes and tropical storms pose significant risks to public safety, economic activities and natural resources (Lewsey, Cid and Kruse, 2004).

Increased atmospheric temperature

Jamaica has experienced an increase in average temperatures over the last century. Data accessed through the World Bank Climate Change Knowledge Portal indicate that Jamaica's average summertime temperatures (June to August) increased by 0.86°C from the 1901-1930 period to the 1991-2020 period. Summertime temperatures are critical to consider as this represents the extreme threshold of the annual cycle. Increased temperatures have direct impacts on human health and the agriculture sector.



The Conference on Human Health and Global Climate Change Summit (1996) identified that exposure to heat waves and the experience of heat stress is the most significant impact on

communities. Other threats identified include increased risk of vector borne diseases and non vector borne diseases which have seasonal patterns.

Jamaica's Ministry of Health and Wellness released an advisory to the public in 2023 noting extremely high temperatures were being recorded and warning members of the public to be mindful of heat stress with symptoms from rashes and cramps to life threatening symptoms associated with heat stroke. 2023 was the hottest year on record. The advisory also stated that the most vulnerable groups to heat stress were the elderly, young children and persons who are overweight.

Increased atmospheric temperature impacts agriculture by increasing evaporation and evapotranspiration rates which reduces soil moisture content. To maintain moisture content more water is required during the production of crops which increases the cost of production. Extremely high temperatures can also reduce photosynthesis and can cause crops to wilt and die (Inter American Development Bank, 2014). The community of Oracabessa has an important agriculture sector that is at risk of these impacts.

The vulnerability of human health and agriculture extends to the community of Oracabessa. It affects all residents by exposing them to health risks, economic impacts within the agriculture sector and food security. All these impacts will also have an impact on tourism as visitors from colder climates would be less adapted to temperature conditions in Jamaica. This could act as a deterrent to visitors and also put those persons who do visit at a risk of heat exposure.

Increased Sea Surface Temperatures

Sea surface temperature (SST) is the temperature of the sea at its surface. In extra polar regions (60°N to 60°S), sea surface temperatures (SST) have increased by 0.9°C from pre industrial times. The graph below illustrates the increase in SST from 1850 to 2023.

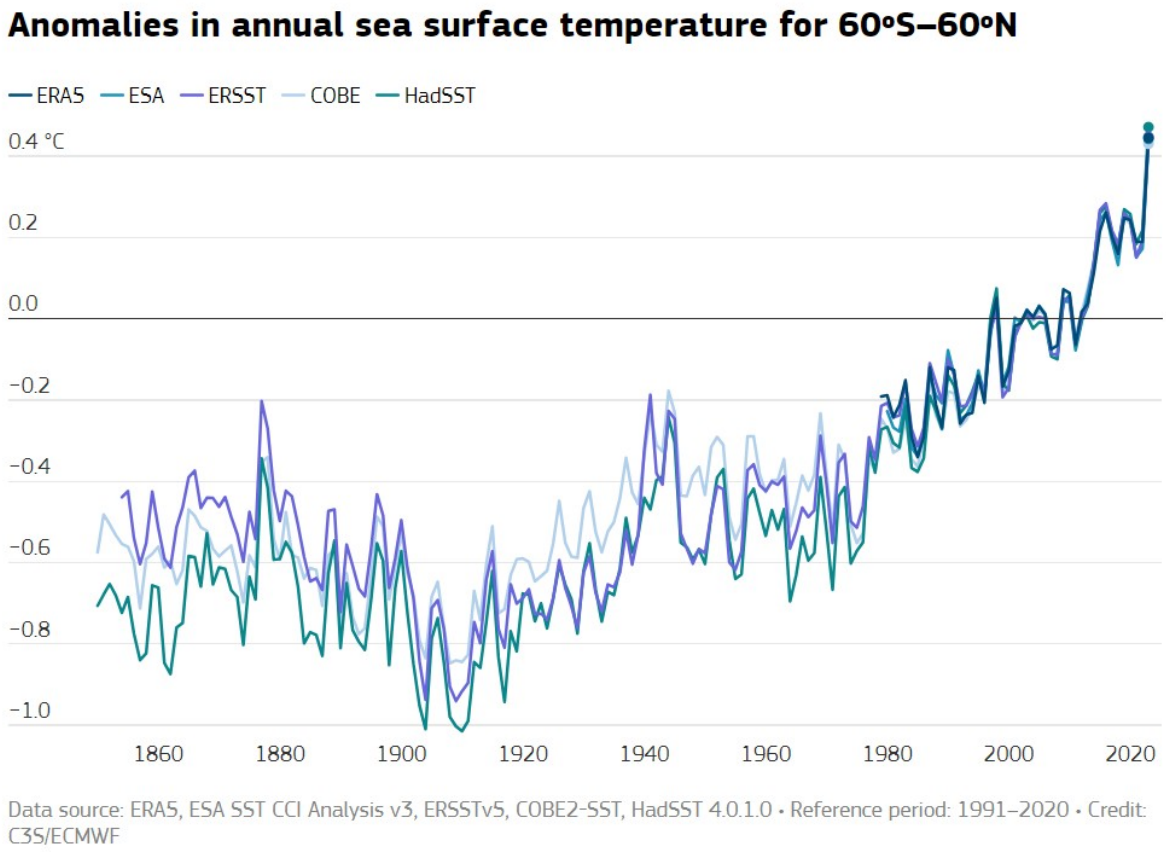
Elevated sea temperature causes large-scale coral bleaching in coral reef ecosystems. Bleaching occurs when temperature increases by 1 to 2 degrees Celsius above normal within a particular location. Prolonged bleaching leads to mass coral mortality and causes major disruptions to the structure and functioning of coral reef ecosystems. Increased frequency and severity of bleaching events is recognized as the greatest threat to coral reefs on a global scale (United Nations Environmental Program, 2017)

There have been 4 coral bleaching events classified as 'global bleaching events' due to their geographic extent. The first was in 1998, then 2010 followed by the three year period from 2014 to 2017. The most recent mass bleaching event started in 2023 and is still ongoing. More than 70.7% of coral reefs across the globe have been exposed to bleaching level heat stress since January 1, 2024 (NOAA; May 23, 2024). All these global bleaching events were experienced in Oracabessa.

The Oracabessa Marine Trust has reported that the current bleaching event is the worst experienced in Oracabessa to date, and that the level of mortality is very high, though it has not been scientifically quantified as yet.

Coral reefs consist of multiple species of corals that have different responses to increased temperatures. Some are very susceptible to bleaching while others are more resilient. Also within a single species great variations have been found in bleaching response. It has been argued that increasing sea temperatures may cause corals to go extinct, however research is ongoing and it is not clear that corals will go extinct, though significant changes have been and will continue to take place.

A study on the Australian great barrier reef found that there are significant relationships between live coral cover and fish abundance as well as coral diversity and fish diversity. The study found that variations in coral species richness explained 63.6% of the variation in fish species richness and live coral cover explained 17.4% of the variation in fish abundance (Komyakova, Munday and Jones, 2013). While these relationships have not been quantified in Oracabessa, it can be assumed that loss of live coral cover will affect fish abundance and diversity.

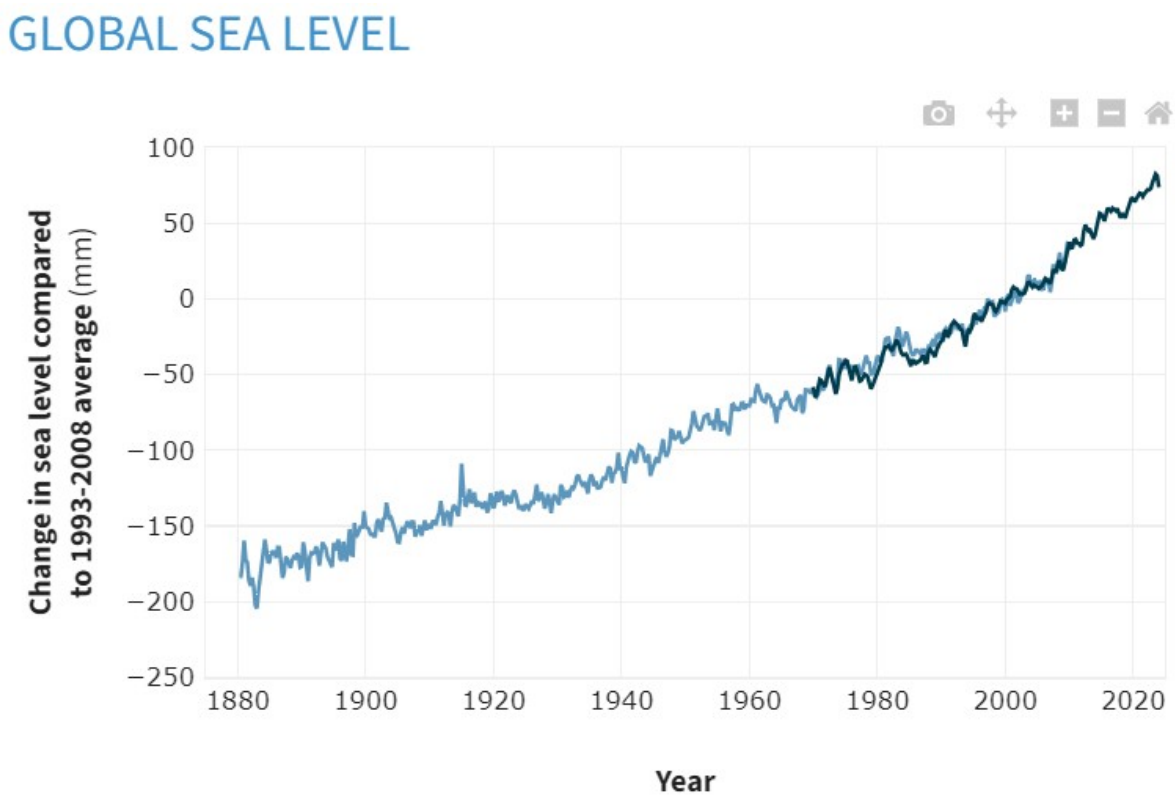


Increased sea temperature does not have a direct impact on individuals in the community but through the impact on reef health it is a threat to the local fisheries sector, food security and the tourism sector.

Oracabessa is a tourism destination that is becoming increasingly popular for ecotourism. Coral reefs are a major attraction for snorkelers and divers, and they are an important tourism product for the two major hotels and several small villas within the vicinity of Oracabessa. Two of the hotels offer water sports, including SCUBA diving and Snorkelling while the marine protected area in Oracabessa provides an independent watersports operation option for persons not staying at one of these hotels.

Sea Level Rise

Global sea level has risen by 25 cm since 1880, and the rate of sea level rise has been increasing in recent decades. By the end of the century sea level is expected to be about 60cm higher than the year 2000. Sea level rise poses a direct threat of submerging coastal resources and causing saltwater intrusion in groundwater systems. It also increases the exposure of coastal resources to storm surge and storm wave energy.



Projected global sea level rise (NOAA, 2022)

Fortunately, Oracabessa has high land elevation within a very narrow coastal plain. As a result, the threat of sea level rise does not extend very far inland. However, there are significant tourism, fisheries and recreational resources along the shoreline that are exposed to sea level rise. There are two fishing beaches and 4 recreational beaches that are at low elevation within the community. All these beaches are at low elevation and most are small

beaches. An increase in sea level of 60 cm above the year 2000 level would cause significant loss of beach area from erosion.

The community of Oracabessa has very deep water just offshore with limited coastal shelf to break wave energy, and so it is exposed to strong wave energy from storm systems. Ecosystems, ~~-~~ bB**oats and infrastructure along the shoreline are exposed to strong wave energy and storm surge and will be more exposed with the projected sea level rise.**

Google earth image of Oracabessa showing the raised elevation of the town. The dark blue area is very deep water.

Coastal erosion and exposure to wave energy is a major threat to fisheries and tourism, which are both concentrated along the shoreline. As a result, the potential economic impact of sea level rise is very large for the community.

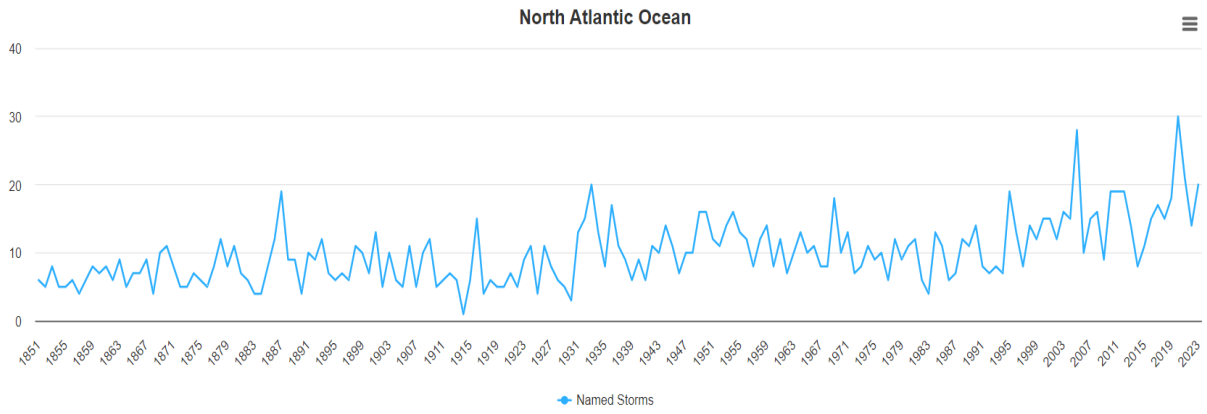
Increased frequency and strength of storms:

There has been an increase in the intensity and frequency of storms in the last 5 to 6 decades. The following information is sourced from the Environmental Impact Assessment conducted for the development of Goldeneye Resort:

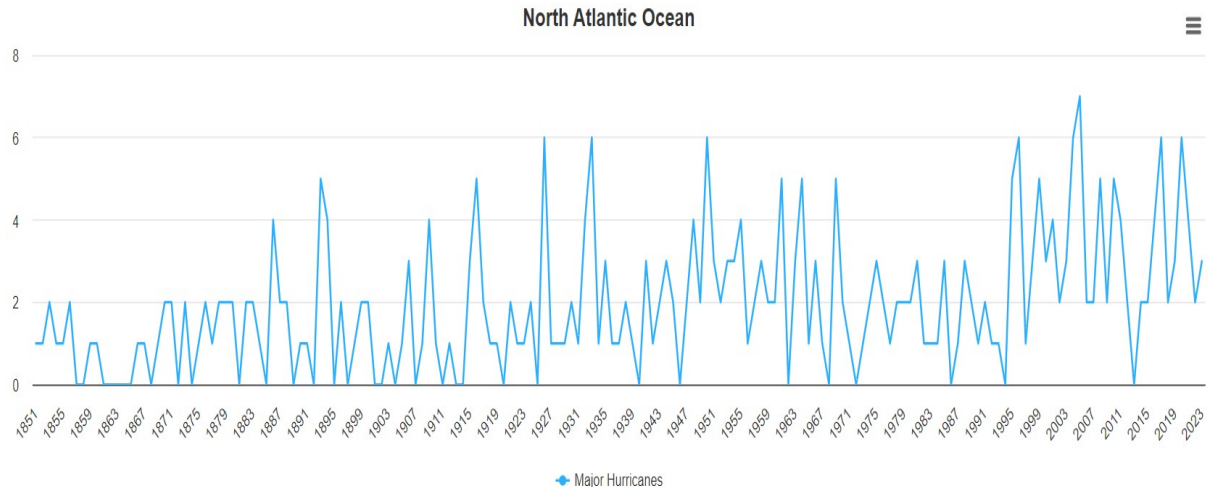
The number of named storms increased from between **6** ~~to~~ and **9 named storms per year (1850 to 1870), to** between **10** ~~to~~ and **30 named storms per year (2000 to 2020). The frequency of major storms increased from less than 3 per year from 1850 to 1870 up to 7 major storms per year from 2000 to 2020 (Colorado University, 2024). The increase in** named **storms** and major storms is of significance to Jamaica as ~~ma A~~a**pproximately 14% of storms from 1880 and 1980 passed within 161 kilometres from Oracabessa with a recurrence interval of 5.5 years.**

Hurricane Allen (1980) passed within 32 km of the north coast in August 1980 with winds of 115 knots. Storm surges of over 3 m were recorded at Oracabessa. This is the only

documented case of storm surge impact **in the area. The propensity for flooding from heavy rains and storm surge exists particularly in the vicinity of Jacks River mouth in the centre of Oracabessa Bay. The level of impact from hurricane winds and rough seas depends on the angle of approach and the strength of the storm. For example, hurricanes Gilbert (1988) and Ivan (2004) did not cause much coastal marine damage in Oracabessa because their tracks were south of the area. Hurricane Dennis (Category 2, July 2005) passed about 40 km north of Oracabessa without inflicting very much coastal damage.**



Number of named Atlantic storms per year from 1851 to 2023 (Colorado State University, accessed June 2024)



Number of major Atlantic hurricanes per year from 1851 to 2023 (Colorado State University, accessed June 2024)

There is a lack of historical data on the impact of hurricanes on reefs in Oracabessa. However, there is documentary evidence of significant damage from hurricanes on coral reefs on Jamaica's north coast.

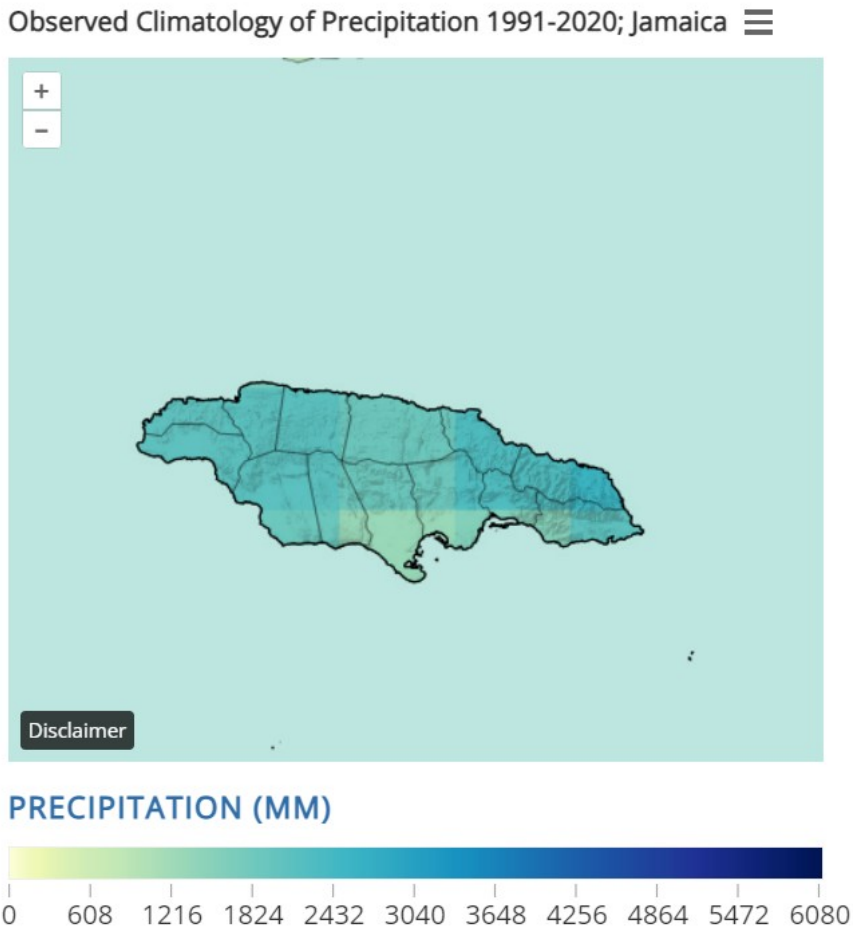
Studies in Discovery Bay, about 50 km to the west of Oracabessa, have documented that in the 1950s to 1960s reefs were dominated by thickets of branching corals in the shallow zones. These large thickets of live coral were 'wiped out' by hurricanes in 1980 and 1988. Reefs on the north coast have never fully recovered from this hurricane damage (Woodley, 1992). With more major storms impacting and passing close to the island in the last two decades, the time between storm impacts has reduced, which limits the opportunity for recovery of coral reefs between storm events.

Hurricanes can result in loss of life, displacement, and economic hardship for residents. They also disrupt tourism and other economic activities, leading to financial losses for local businesses and the national economy. The damage that hurricanes have caused on reefs on Jamaica's north coast has probably resulted in significant impacts to the local fisheries sector from the 1980s onward.

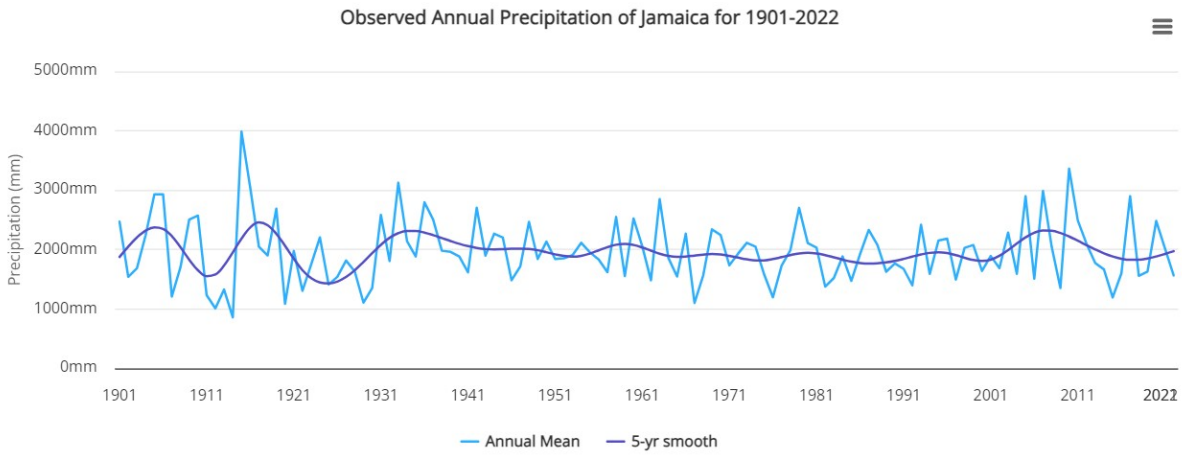
Changing rainfall patterns

The total amount of rainfall received by Jamaica has remained fairly consistent from 1901 to 2020. However with increased storms the distribution of rainfall may be changing, with more rainfall being concentrated around storm events periods and less rain in between.

Oracabessa is within an area of Jamaica that receives more rainfall compared with other locations and so is typically less prone to drought. Flooding is also not a major threat due to the elevation of the town and the limestone geology which allows quick soaking away of rain water.



Rainfall distribution across Jamaica (World Bank, accessed 2024)



Annual rainfall in Jamaica from 1901 to 2022 (World Bank, accessed 2024).

Continued effects of climatic changes in the project area

Climate change is expected to continue into the future. Five potential scenarios for future climate change have been presented by the IPCC. The most likely scenario would see a 2.8 degree Celsius increase in global temperature by 2100. If humans are able to improve technology and energy sources then temperatures may eventually reduce as carbon is cycled out of the atmosphere, but current forecasts project continued increase in temperature over the coming decades.

Therefore, all the impacts outlined above are expected to continue affecting the community of Oracabessa and even increase in severity over the coming decades. Adaptation strategies are therefore going to be very important, both for ecosystems and the community.

Exposure to natural hazards and sea level rise will be particularly significant along the shoreline where beaches and infrastructure related to the fisheries and tourism sectors are particularly vulnerable. Increasing sea temperature will also continue to be a major threat to coral reefs. High rates of coral mortality are expected to continue. Some experts have predicted that some species of corals may go extinct within the current century. The cascading effects of coral mortality on the reef ecosystems are expected to cause significant changes to coral reefs, but the specific changes are yet to be seen.

PART III: Habitat restoration, ecological management and livelihood adaptation strategies

The Caribbean EBA project uses ecosystem based adaptation strategies to reduce the impact and risk associated with climate change hazards and threats. The table below presents a range of EBA options for the climate change impacts identified in section II off this literature review.

Climate change hazard	EbA options for population in general	EbA options for fisheries	EbA options for agriculture	EbA options for tourism
Increased atmospheric temperature	Tree planting to provide shade? Raising awareness about risk of vector-borne disease?	n/a (not a major threat)	Tree planting to provide shade? Agroforestry? Changing crops?	Tree planting to provide shade? Raising awareness about risk of vector-borne disease?
Increased Sea Surface Temperature	n/a (not a major threat)	Coral reef restoration Reducing non-climatic pressures on coral reefs and fish stocks	n/a	Coral reef restoration Reducing non-climatic pressures on coral reefs Reducing water

				pollution from agriculture
Sea Level Rise	n/a (not a major threat)			
Increased frequency and strength of storms				
Changing rainfall patterns				
Others? (e.g. salinisation of groundwater?)				

Climate change adaptation strategies have become increasingly important for marine ecosystems and the communities and livelihoods that they support as climate change impacts have become more severe. Natural systems and species will adapt to their changing environment without human intervention, but the scale and rate of climate change has put ecosystems under significant pressure to the point where they are unable to adapt at a fast enough rate. Human systems adapt through complex frameworks and principles of adaptation planning. However, concrete examples of implementation of adaptation initiatives are scarce (Miller et al., 2018).

Impacts and threats from climate change add to other pressures from human activities to threaten the ecosystem benefits provided to a community. Climate change adaptation strategies seek to either reduce the exposure of ecosystems to climate hazards or to increase and support the endogenous capacity of the ecosystem to adapt to climate change (Johnson and Helbrook, 2014). Another way to increase the resilience of

ecosystems to climate change is to reduce non climate stressors to increase the ability of ecosystems to recover from climate change impact stresses (NOAA, 2021).

For the community of Oracabessa, coral reefs, seagrass beds and sandy bottom habitats make up the ecosystems along the shoreline. Of these, coral reefs are the most susceptible to climate related impacts. Storm damage and increased temperature currently pose the greatest threat to reefs.

Ecosystem management and habitat restoration

Coral restoration

Restoration efforts can be very effective at increasing live coral cover within relatively short periods of time. An active coral restoration program was implemented in Oracabessa in 2009, which has seen the outplanting of over 30,000 corals. Corals are grown in nurseries and introduced into the wild by 'planting'. This activity increases the number of corals in the wild and has benefits to the ecosystem. These include:

- Increased habitat space for fish
- Increased reef building effect of coral growth
- Increased densities of reproducing corals
- Increased chance of reproductive success during coral spawning
- Assisted evolution of corals by speeding up the replication of resilient corals

These benefits will help reefs to continue to grow in the face of sea level rise and warming sea temperatures, while continuing to provide the habitat structure that will help mitigate changes in the ecosystem structure. Live coral cover also helps with coastal protection from storm waves, and helps reefs to 'regrow' after receiving damage from storm waves.

Coral restoration techniques in Oracabessa

There are 2 phases to the coral restoration program in Oracabessa: Nursery Growth and Outplanting.

Nursery phase

- Nurseries are suspended in mid water to remove corals from predators on the seafloor.
- Nursery growth is for 6 to 8 months
- Corals are monitored for disease and physical damage weekly
- Corals are harvested from the nursery at the end of the growth phase
- Some material is returned to the nursery to seed the next batch of corals (asexual reproduction by fragmentation)

Outplanting phase

- Planting sites are selected based on the following characteristics:
    - Low density of fleshy algae

    - Low coral disease
    - Low numbers of coral predators
    - Good light penetration
    - No water pollution
- Corals harvested from the nurseries are transported to outplanting sites
- At outplanting sites corals are attached to the seafloor using cement or by tying with fishing line.
- Plant site is monitored for predators and to ensure corals attach properly to the seafloor

Climate vulnerability of coral restoration

The coral nurseries are exposed to storm wave conditions. OMT has modified the design of the nurseries over the years, transitioning from line nurseries that are made of rope and fishing line and have 2 anchor points, to 'tree' nurseries that have one anchor point and are built using PVC poles that are more sturdy. This change has made the nurseries more resilient but they are still exposed due to their location.

While coral bleaching is a major threat to coral restoration in Oracabessa, the restoration efforts are in response to climate change, and the impacts of climate change have always been an understood risk.

Coral restoration activities in Oracabessa survived 2 of the 3 mass coral bleaching events that were experienced between 2014 and 2024. However the ongoing bleaching event that started in 2023 resulted in the mortality of all the nursery grown corals in Oracabessa as well as all the wild population.

Strategies for continued adaptation of coral restoration efforts will be explored in the adaptation action plan.

OMT's restoration efforts have continued for 15 years, during which there were major coral bleaching events in 2017,

Ecosystem management

~~Ecosystem management~~Sustainable management of ecosystems can provide~~s~~ climate resilience indirectly by attempting to reduce non climate stressors ~~from~~ on ecosystems. This increases the overall health of ecosystems in the face of climate change.

In Oracabessa, a marine protected area has been the tool utilized to manage the marine ecosystems. Oracabessa Bay Fish Sanctuary is a protected area under the Fisheries Act of Jamaica. While the primary objective of the protected area is to manage fish stock, an Ecosystem Based Approach to Fisheries Management is mandated under Jamaica's

Fisheries Act. This approach focuses on the overall health of the ecosystems that support the fishing industry.

The main mechanism used by the fish sanctuary is spatial management of fishing activities. The protected area restricts fishing within its boundaries, thereby reducing the impact of fishing pressure. This allows fish stocks to increase and has several associated benefits:

- Increased fish populations within the protected area
- Increased fish populations in areas adjacent to the protected area
- Increased grazing of algae by herbivorous fish
- Reduced algae cover on reefs
- Restoration of natural food webs
- Increased diversity of fish species
- Increased diversity of the ecosystem

Some of the secondary activities of the protected area also improve resilience of ecosystems to climate change by addressing pollution and other human impacts. These include

- Solid waste management
    - Beach Cleanups
    - Installation of bins
    - Educational campaigns
- Monitoring coastal development
    - Prevent sedimentation
    - Avoid direct damage to marine resource
- Monitor tourism
    - Prevent pollution
    - Prevent anchor damage
- Invasive species management
    - Remove invasive species
- Promote sustainable fisheries
    - Encourage and support the adoption of fishing techniques and technologies that have less negative environmental impacts
    - Promote fishing laws
    - Support fishers to comply with laws
    - Raise awareness of Jamaica's fisheries and environmental policies

Climate vulnerability of ecosystem management

Ecosystem management activities are exposed to storm damage. The infrastructure and equipment of the protected area include boats, demarcation buoys, signage and an office building. All these are located in close proximity to the sea and some are also exposed to the threat of damage from high winds.

Livelihood adaptation

Climate change livelihood adaptation strategies can focus on improving existing livelihoods or introducing new livelihoods that are less vulnerable to climate change. The livelihoods that are currently in place in the coastal zone are fFisheries and tourism, which are both vulnerable to climate change. Sea Moss mariculture is a proposed livelihood activity. The government of Jamaica has identified sea moss culture as a priority alternative livelihood intervention for the fisheries sector and has implemented programs and provided funding to support its development. Oracabessa has received some support from the government through the Jamaica Social Investment Fund (JSIF) to develop a management plan for sea moss cultivation in Oracabessa.

Fisheries

Fishing activities rely on a range of natural resources, these can be grouped as follows:

- Inputs
  - Wood from the forest to make fish traps
  - Fruits and other products from the forest to use as bait
- Spatial/Geographic
  - Beaches and harbour to safely keep boats
  - Space at sea to carry out fishing activities and safely set their fishing gear.
  - Beaches also provide space for the exchange of fish with customers
- Reef ecosystems
  - Habitat quality
  - Several species of fish

Climate vulnerability of the fisheries sector

Forests support fisheries, but the forests in Oracabessa have not been seen to be badly damaged by climate change to the point where fishers have been impacted. The most significant impacts have been damage to fishing equipment. This has happened both at sea and at the beaches. Fishing gear at sea is more exposed to damage from increased storm activity and has resulted in significant losses. At the beach boats and fishing gear are also exposed to storm damage.

The fishing beaches in Oracabessa are relatively small, which also makes them susceptible to erosion from sea level rise.

The impact of coral bleaching on the quality of habitats and the biodiversity of reef ecosystems poses a threat to the variety and quantity of fish species available for fishers to catch.

Sea moss mariculture

Sea moss mariculture, also known as sea moss farming or cultivation, involves the sustainable cultivation of various species of red algae within marine environments. This

practice is primarily focused on species such as Irish moss (*Chondrus crispus*) and other similar red algae species that are harvested for their valuable properties and uses in various industries, particularly in food and cosmetics.

The activities involved are

- Site selection
  - Relatively calm water is needed
  - Sunlight required for growth
  - Salinity must be high (limited freshwater input)
  - Sufficient nutrients within the water for growth
  - No pollution
  - Good water circulation (minor wave action and/or current flow)
- Set up and seeding of cultivation structures
- Growth and maintenance
  - 'farmers' will visit the structures weekly to monitor growth and remove any other algae growth that could compete with the cultivated species
- Harvesting, drying and processing
  - Picking sea moss from the growth structures
  - Rinsing with fresh water
  - Bleaching and drying in the sun
- Packaging, storage and distribution
  - Placing dried product in packages
  - Storing in cool temperature in a dry place
  - Indoor location

Climate vulnerability of sea moss culture

Sea moss culture is vulnerable to exposure to storm waves and freshwater input from increased rain during storm conditions. However if storm conditions are not prolonged then the sea moss should survive short term changes in salinity. The infrastructure used to grow is relatively low cost and the locations selected for growth would be less exposed to storm waves than the locations that fishers typically carry out their fishing activities. Facilities used to dry and process the product are typically close to the shore and so could be exposed to wave damage as well as wind damage. Storms can also cause spoilage when the product can not be dried in the sun.

Tourism

Tourism in Oracabessa consists of a few small hotels and several villas. There is one large all-inclusive hotel close to Oracabessa where several community members work.

James Bond beach is a very popular beach that is visited by community persons, local Jamaican tourists from outside the community and foreigners. The beach is not fully operational since it shut down following the 2019 COVID pandemic. There is a very small scale and infrequent fishing tourism activity that is carried out by fishers who take tourists out fishing. SCUBA diving and snorkelling occurs daily within Oracabessa with the majority of activity being carried out by the all-inclusive hotel that is located nearby. Since the

establishment of the Oracabessa Bay Fish Sanctuary, locals have had the chance to enter the marine tourism sector by working in the Dive Shop at Oracabessa Bay Fish Sanctuary. More locals are now able to work as tour guides, dive masters, boat captains and snorkel guides. Outside of the hotels, the protected area is the only other opportunity for marine ecotourism in Oracabessa.

Vulnerability of tourism livelihoods

Tourism livelihoods are dependent on the quality of the marine environment. The sector also needs good quality beaches and relies on infrastructure in close proximity to the sea. All the potential impacts on the marine environment and exposures to threats associated with storms and sea level rise therefore also apply to the tourism sector.

Recommendations for the EbA Project

The EbA project aims to use ecosystem restoration and livelihood interventions to increase climate change resilience in the community of Oracabessa. The climate trajectory to date and the various potential future scenarios indicate that the negative impacts and threats that result from climate change will become more severe in the coming decades. The project must therefore not only be sensitive to the existing climate vulnerabilities, but the future vulnerabilities as well.

The community of Oracabessa is most susceptible to storm wave damage, coral mortality from ocean warming, damage from storm winds and exposure to heat stress. The proposed project activities involve growing and planting corals, which includes the placement of infrastructure to facilitate coral restoration. It also includes building capacity around more sustainable livelihoods through training and the provision of infrastructure and equipment.

The project can be made more climate resilient by considering storm wind and wave risks when placing infrastructure and by having a disaster plan that secures the various equipment provided. Training activities should be used to disseminate climate adaptation best practices that consider the specific vulnerabilities of the community. Adaptation measures that consider the community's vulnerabilities must be built into the design of all the livelihood interventions and all the educational resources produced under the project. The internal operations of the protected area management system should also be revisited during the review of SOPs to ensure that disaster response is adequately considered.

Disaster response/management plans should include the following:

1. **Risk Assessment and Vulnerability Analysis:**
    a. **Identify the specific locations and level of threat of potential hazards that could affect the community or environment (e.g., Siltation, chemical spills, coastal erosion, heavy storm waves etc).**
    b. **Assess the level of vulnerability of ecosystems, species, habitats, and infrastructure to these hazards.**
2. **Early Warning Systems:**
    a. **Establish or utilize existing systems for early detection and warning of potential disasters, such as monitoring weather forecasts.**
3. **Response Team and Communication Protocols:**
    a. **Define roles and responsibilities of personnel involved in disaster response (e.g., MPA staff, emergency services, local authorities).**
    b. **Establish clear communication protocols and lines of authority to ensure efficient coordination during emergencies.**
4. **Emergency Procedures:**
    a. **Develop step-by-step procedures for different types of emergencies, including evacuation protocols, containment and cleanup of spills, rescue and rehabilitation of marine life, and protection of sensitive habitats.**

    b. **Include protocols for notifying and involving relevant stakeholders, such as nearby communities, government agencies, and environmental organizations.**
5. **Resource Inventory and Equipment:**
    a. **Maintain an inventory of resources and equipment available for emergency response (e.g., boats, communication devices, medical supplies).**
    b. **Ensure regular maintenance and readiness checks for all equipment.**
6. **Training and Drills:**
    a. **Conduct regular training sessions and drills for response teams to practice emergency procedures and improve response efficiency.**
    b. **Include training on specific skills needed for marine environments, such as wildlife handling and marine pollution control.**
7. **Community Engagement and Public Awareness:**
    a. **Educate local communities and stakeholders about the role they can play in climate vulnerability preparedness and response.**
    b. **Develop outreach materials and communication strategies to inform the public about climate adaptation procedures and measures.**

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